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INNOVATION

NASA's Assistive Technologies Benefiting People

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COMMERCIAL DEVELOPMENT MISSION UPDATE

Date*	Flight	Payload	Sponsor/Coordinator
11/01	STS-108/ISS Flight "UF-1"	Advanced ASTROCULTURE™	Wisconsin Center for Space Automation and Robotics
		Zeolite Crystal Growth (ZCG)	Center for Advanced Microgravity Materials Processing
		Commercial Biomedical Testing Module (CBTM) (Sortie)	BioServe Space Technologies
2/01	ISS Flight 8A	Zeolite Crystal Growth (ZCG)	Center for Advanced Microgravity
		Commercial Generic Bioprocessing Apparatus (CGBA)	BioServe Space Technologies
		Commercial Protein Crystal Growth (CPCG)	Center for Biophysical Sciences and Engineering

* As of October 2001.
STS—Space Transportation System
ISS—International Space Station

WELCOME TO INNOVATION

NASA Technology Assists People Through US Industry

By Merle McKenzie,
Manager of the Commercial Technology and Regional Development Program at the Jet Propulsion Laboratory

IN 1958, CONGRESS CREATED NASA, GIVING the agency direction to lead America's space program. It also mandated that the agency make available to the US industrial community the leading-edge aeronautics and aerospace technologies required for NASA's ambitious missions. For many years, the advanced technologies generated by NASA's technical communities have been successfully leveraged through NASA's commercialization program for the benefit of US industry. Companies who have partnered with NASA or licensed NASA technology have created new products, improved existing products and/or made internal processes more efficient. The result has been a positive impact on local, if not national economies, and notable increases in competitiveness.

Examples of technologies that have been successfully transferred by private industry are legion. They range from technology that makes de-icing a plane's wings safe and cost-effective to non-invasive tools that enable "machines to smell" on the International Space Station, as well as on the ground; from developing a new curriculum to educate the space explorers of tomorrow to improved active pixel sensor cameras for spacecraft, as well as consumer products. The years have proven that advanced NASA technology can and is commonly used by US companies to improve their bottom line.

Yet, that is just the perspective of those involved with the government missions and the private sector. Through the history of the NASA commercialization program, these effective partnerships have also benefited a third party who directly gains from NASA's cooperation with US industry through products that would not have been available otherwise. NASA technology and US companies have contributed notable advanced technologies for assistive products for daily life.

A few cases of NASA technology leveraged for assistive products are: a robotic stepper device developed from technology at the Jet Propulsion Laboratory that may help wheelchair-bound people take their first steps; a new material from the Marshall Space Flight Center that can be used to produce master molds for prosthetic devices; an initiative encouraged and partially funded by Goddard Space Flight Center to study the effect of patient-friendly technology on pain palliation for terminally ill patients; a selectively lockable knee brace developed by NASA's Marshall Space Flight Center that allows for knee movement, while still providing support for the knee; and an eye tracker that allows people with limited mobility the means to communicate and control their environment. The latter, originally developed by a small company in Fairfax, Virginia, is now more compact, ambient light tolerant and marketed at a lower price through technical innovations from the Jet Propulsion Laboratory. In cases such as these, the company has utilized the advanced technology developed by NASA to develop new products or improve existing ones. The ultimate beneficiaries are the assistive technology users, who gain leverage or ease in daily living, making these triple-use technologies.

Success in this arena is not easy; many difficulties arise in the commercialization of these technologies. There is no one single "assistive technology" market. Instead, there are a number of small niche markets. Owing to the small market size and the need to customize a device for each user type, few economies of scale can be practiced, and some devices are not covered by insurance. Also, a relatively small number of companies are serving the niche markets.

Additionally, "one size fits all" does not work in this market. Many times, the commercial product must be adapted or fitted to individual users, and commonly requires training for ease of use. It is especially important to work with the user community when developing and manufacturing assistive technologies.

Because the respective markets are relatively small, the user community has such significant requirements and the ultimate use is frequently customized, it is an area in which normal market forces do not necessarily result in a high volume of advanced technology moved quickly to market by early adopters. It is instead an appropriate area in which government-funded technology should be leveraged wherever possible. Although not easy, by collaborating with both private industry and the end-users, NASA can continue to make significant contributions to everyday lives.

NASA's Assistive Technologies Benefiting People

WHAT DO A KNEE BRACE, AN EYE TRACKER, using telemedicine to ease pain, and robotic stepper devices have in common? They are all NASA-developed technologies that can be used as assistive technologies.

These examples are only some of the technologies that NASA has developed over the years that serve as assistive technologies. Some of these advanced technologies were developed specifically for an assistive purpose. Other high-tech gadgets were developed for use by NASA and have been adapted by companies to develop new products or improve existing ones.

Vernotto C. McMillan, manager of MSFC's Technology Transfer, said, "A technology transfer that directly benefits mankind is always a great success story. As we develop new space and propulsion technologies in the future, it is imperative that we begin with the end in mind. We call this commercialization planning, and it allows us to explore potential uses of mission technologies prior to their development. In the end, NASA will have a technology that meets mission requirements, and US industry will have a technology that lends itself to a commercial product."

Currently being manufactured by LC Technologies, Inc. of Fairfax, Virginia, the Eyegaze system, incorporating the latest JPL-developed technological enhancements, is used primarily by people with severe spinal injuries. The device allows people with disabilities to communicate and have some control over their surroundings.

According to Al Pappano, manager of JPL's Collaborative Technology Development Office, there are difficulties when commercializing these technologies. "There isn't one assistive technology market," Pappano said. "There are many small markets, which makes it difficult for commercial companies to produce these devices economically. Instead, a better approach is to develop technologies that can be used by the larger markets and, with some modifications, will result in products that are affordable by people who need assistive technologies."

Several NASA technologies are now being used or are in the process of being developed for use as assistive technologies; these include:

- Selectively Lockable Knee Brace—Developed at Marshall Space Flight Center
- Master molds for prosthetics—Developed at The Harshberger Prosthetic & Orthotic Center, Inc. in Birmingham, Alabama
- Study of pain palliation for the terminally ill—Encouraged and partially funded by NASA's Goddard Space Flight Center
- Advanced eye tracker systems—Developed at NASA's Jet Propulsion Laboratory
- Robotic stepper—Developed at Jet Propulsion Laboratory

The Selectively Lockable Knee Brace allows for a full range of movement of the knee. Previous knee braces on the market locked the knee in a rigid, straight-leg position. The MSFC-developed knee brace utilizes mechanical actuator technology used in steering spacecraft and can be used to help patients who have a loss of muscle control from the thigh down. The brace may be used when a patient recovering from a knee injury needs to use the knee, but the knee cannot carry the patient's full weight.

The Harshberger Prosthetic & Orthotic Center applied NASA technology to manufacture its orthopedic appliances, such as artificial limbs. The company replaced plaster and cornstarch materials used to produce prosthetic plaster molds with the foam insulation system used to protect the space shuttle external tank from excessive heat.

The study of pain palliation for the terminally ill determined the effect of patient-friendly telemedicine technology on underserved uptown Manhattan

minority communities of Harlem, Washington Heights and Inwood. The research program involves a partnership between North General Hospital, Memorial Sloan Kettering Cancer Research Center, the New York Visiting Nurse Service and the Center for Technology Commercialization, Inc. (NASA's Northeast RTTC). The study is being funded through a grant from the Department of Commerce, with matching funds from the Upper Manhattan Empowerment Zone Development Corporation. The technology focus of the program involves a consumer-friendly telephone- and television-based system developed in Canada. The work will utilize some NASA-developed telemedicine technologies as well, principally those of CyberMDx of Houston, Texas. Twenty-

SCIENTISTS AND RESEARCHERS AT THE 10 FIELD CENTERS HAVE DEVELOPED TECHNOLOGIES ON A CASE-BY-CASE BASIS FOR INDIVIDUALS WITH DISABILITIES.

Several technologies originally developed by NASA for the space program have found new uses as assistive technologies. This display shows some of the technologies that have been successfully commercialized.

Harshberger Prosthetic & Orthotic Center, Inc. in Birmingham, Alabama uses the same foam insulation system utilized to protect the space shuttle external tank from excessive heat to produce prosthetic master molds. The more efficient foam insulation has replaced the plaster and corn starch materials previously used.

five telemedicine modules and the accompanying hardware (for remotely measuring blood pressure, temperature, weight, blood glucose, EKG, etc.) will be installed in the homes of terminally ill cancer, AIDS, congestive heart disease, pulmonary disease and diabetic patients to improve medical care and control pain. Over the course of the two-year study, the participation of a total of about 300 patients in the test and control groups is anticipated.

The advanced eye tracker systems allow people with disabilities to communicate and have some control over their surroundings. The Eyegaze system is currently being manufactured by LC Technologies, Inc. of Fairfax, Virginia. The technology incorporates the latest JPL-developed technological enhancements and is used primarily by people with severe spinal injuries and those with Amyotrophic Lateral Sclerosis (Lou Gehrig's Disease). The device works by mounting a small video camera under a computer monitor to look at the user's eye. The user looks at points on the computer monitor to cue the camera, which records the reflection of light from the eye and derives the gaze direction that then guides the cursor. In addition, it is being used to provide access to PCs for communication. The user can type a message for e-mail or make a phone call using dialer software and a voice synthesizer to speak for them. The technology allows access to games and screens for the operation of control devices, and users to regulate lights and the temperature of the surroundings, as well as operating audio and TV equipment.

The robotic stepper is designed to become the basis of a rehabilitation approach that can potentially help people wheelchair-bound take their first steps. The stepper looks like a standard treadmill with robotic arms attached to the front. The treadmill is used in conjunction with a suspension harness that is used to variably support the patient's weight while walking on the treadmill. In addition, the device takes precise force, torque, acceleration and resistance measurements of the patient's movements, assessing each step the patient takes on the treadmill.

Many NASA technologies can be used to improve quality of life and provide assistance. Scientists and researchers at the 10 field centers have developed technologies on a case-by-case basis for individuals with disabilities.

"There are many reasons NASA researchers are working to develop these technologies," Pappano said. "Most believe that applying their skills and technology to help people with disabilities is the right thing to do."

For more information, contact Merle Mckenzie at the Jet Propulsion Laboratory, ✉ *merle.mckenzie@jpl.nasa.gov*. Please mention you read about it in *Innovation*.

SureBolt™ Gage System Commercialized

A PRIVATE FLORIDA ENTERPRISE IS MARKETING a highly accurate ultrasonic bolt gage invented and patented by NASA at Kennedy Space Center (KSC). American Remote Vision Company (ARVC) of Titusville, Florida is offering the SureBolt™ system, which includes a laptop computer.

NASA engineers used the prototype to remotely measure tension in critical bolts attached to a Space Station structure and its six access hatches during preflight pressurized verification testing. Using a digital signal processing (DSP) technique, the gage proved more reliable on every test and bolt than other ultrasonic bolt gages used during the tests.

ARVC's owner, Dr. Stuart M. Gleman, says this is because the existing products are "one point" gages that are unreliable due to peak jumping, and they require a high level of training to operate. SureBolt™ analyzes bolt tension instead of torque and uses the entire echo for more reliability, accuracy and ease of use. Competing products offer at best a monochrome five-inch display with cryptic keys and operating systems lacking user-friendly software.

The company is offering SureBolt™ for $24,500, which includes a Panasonic Toughbook laptop with 13.3-inch screen, 64 MB RAM, three-year warranty, MS Windows 98/2000 operating system, MS Office and a full-size keyboard. The SureBolt™ hardware uses the CD bay and one PCMCIA type-2 slot. The software interface offers ease of use, with tension change graphing in real-time, easy-to-enter notes, special parameters, tension calibration constants and temperatures. Close to one million measurements in Excel-compatible format, with the associated pulse waveform, can be stored automatically.

The prototype was developed in response to a NASA requirement to measure bolt tension on the International Space Station Node 1 during structural test article proof tests. The inventors were employed by I-NET, Inc., the former KSC engineering support contractor. They met NASA's need for a more reliable gage capable of taking multiple measurements (eight bolts at a time) and with the ability to read remotely from 400 feet away while the node was being pressurized.

Also, it was found that commercial bolt gages did not work well on the 1-inch- and 2.25-inch-long (0.25-inch diameter) Space Station bolts, and torque wrenches were known to be only +/- 20 percent reliable. With its digital signal processing technique, the prototype met and exceeded these challenges, working well on 100 percent of all tensions and all bolts. NASA engineers were so impressed with the prototype's accuracy that it was used to test other Space Station bolts.

Left, the readout from a measurement taken with the SureBolt system. Right, a laptop using the SureBolt software and equipment.

In the 30 years since the ultrasonic bolt gage was first invented, many methods have been tested to increase the level of repeatability and confidence in the accuracy of the readings taken with these instruments. When a modern ultrasonic bolt gage and its operator are performing properly, these instruments can measure to an accuracy of +/- 2 percent. However, since bolt gage receivers can and often do "jump peak," or trigger on an adjacent peak in the ultrasonic echo with a corresponding error in the pulse time of flight, a user's confidence in the data collected is significantly reduced.

Therefore, a need has long existed for a more reliable ultrasonic bolt gage. Gleman explained that the KSC innovation employs the concept of using the entire ultrasonic waveform, rather than just a feature of the waveform such as zero crossing, to find the time of flight of the ultrasonic echo. In addition, once the waveform is digitized and captured, features such as zero crossings can be identified and tracked which again leads to increased performance reliability of the overall instrument.

The prototype SureBolt™ combined a correlation bolt gage with three independent feature-recognition bolt gages, all operating on the same captured waveform. The prototype's architecture allowed for operation of the system from a remote host computer and handled multiple bolts (sequentially, not simultaneously) under remote control. Data from the independent bolt gages were compared by the computer, resulting in a final tension number with a reliability estimate of that number.

The final result of NASA's bolt gage research and development will be increased reliability of tension measurements in critical fasteners in all industrial, infrastructure and military applications, with a corresponding increase in safety and mission success probability.

For more information, contact Lynne Henkiel at NASA Kennedy Space Center, 321/867-8130, *Lynne.henkiel-1@ksc.nasa.gov*. Please mention you read about it in *Innovation*.

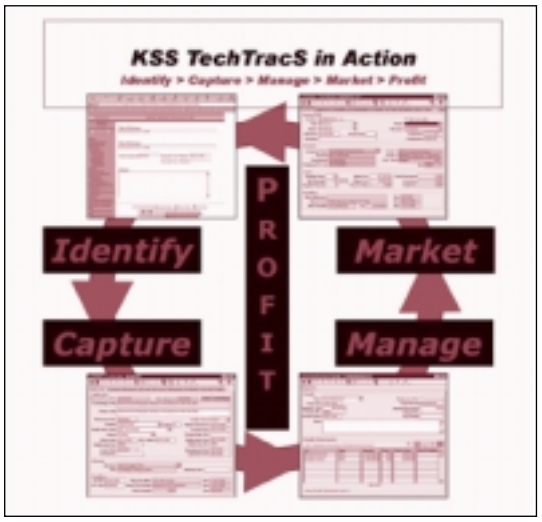
NASA Spin-Off Company Enjoys Commercial Success

NASA TECHNOLOGY DEVELOPED FOR SPACEcraft and aircraft often finds applications in more terrestrial applications such as manufacturing or healthcare. It is a common outcome for the benefits of NASA's Research and Development (R&D) to be shared widely with the American public. Recently, in an upshot twist, one of the tools NASA uses to facilitate technology transfer has found itself commercial success.

NASA TechTracS was created to help manage the technological fruits of NASA's annual $13 billion R&D efforts. It enables the identification, capture, management, sharing and benefits of NASA's discoveries and innovations. NASA TechTracS traces its roots to the mid-90s, when NASA redesigned its technology transfer and commercialization processes, methodologies and objectives. This thorough engineering process took several years to complete and involved the efforts of many dedicated civil servants. In 1998, several key individuals involved with implementing these new policies formed Knowledge Sharing Systems, Inc. to provide intellectual asset management products and services to R&D organizations around the world.

Knowledge Sharing Systems (KSS) developed KSS TechTracS to provide the same intellectual asset management to universities, federal laboratories and private companies. Available since March, KSS TechTracS has been wildly popular with those who have seen a product demonstration. KSS originally partnered with the University of North Carolina at Chapel Hill, North Carolina State University and Michigan Tech to serve as beta test sites. Today, their client list includes Carnegie Mellon University, University of Pittsburgh, University of Louisville, Cornell University and several others. The Department of Energy's Lawrence Livermore National Laboratory and the National Institutes of Health have also retained KSS to build their intellectual asset management systems.

Knowledge Sharing Systems' TechTracS provides intellectual asset management to universities, federal laboratories and private companies.



KSS TechTracS provides users with the ability to easily capture innovations at the research bench. It provides tracking tools that enable strategic decision-making about how to protect and leverage these intellectual assets. It manages invention disclosures, agreements, licenses, royalty streams and filing deadlines in a powerful relational database with enterprise-wide access.

With KSS TechTracS, R&D organizations have a suite of tools at their fingertips to ensure that innovations are managed with the same precision and strategic intent as physical assets. The system enables individually tailored access to professionals so that everyone involved with technology management can contribute their value-added expertise. Patent attorneys, licensing managers, marketing specialists and others all use the same system. For the clients who have installed it, KSS TechTracS has become an invaluable tool to ensure maximum value from their intellectual assets. For example, the Process Automation Manager™ automatically generates standard correspondence, deadline reminders and task assignments, saving hours of staff time to do the same tasks.

Presently, KSS employs 24 people and is projecting sales and employment growth over the next few years as word of its products, services and successes spreads. "The experience gained from designing NASA's technology transfer processes and converting this knowledge into a software product has been invaluable," says Kevin Barquinero, president and chief strategist of KSS. "What we learned at NASA applies to nearly any university or company that conducts research. We really understand the innovation process and how to maximize its capture and value in any organization."

KSS is now developing additional features such as CRADA Manager, Edison Reporting, Advanced Financial Management, Marketing Manager and others to further improve the product. An enhanced version, KSS TechTracS 2.0, was released in October and is now being installed at several client locations. The next product upgrade is slated for release in February 2002.

KSS is yet another example of NASA's success in sharing its expertise with the American public.

For additional information or a product demonstration, contact Bob Cone at 303/902-4350, *bcone@knowledgesharing.com*, or visit the company's Web site at *www.knowledgesharing.com*. Please mention you read about it in *Innovation*.

Technology Helps Weekend Photographers Be Pros

IF A PICTURE IS WORTH A THOUSAND WORDS, new image-enhancement technology, jointly developed by NASA and industry, will increase the average photographer's vocabulary many times over.

This new development will especially help weekend photographers who use the increasingly popular digital format. Digital images of family, friends or one's favorite hobby can be corrected for many common problems with help from this award-winning technology.

The technology, called Retinex Imaging Processing, could be used to enhance the billions of images captured each year by a growing number of low-cost digital color cameras, color printers and desktop and Internet publishing programs.

The process was originally developed for remote sensing of the Earth by researchers at NASA's Langley Research Center and Science and Technology Corp. (STC), both in Hampton, Virginia.

TruView Imaging Company, an affiliate of STC, has licensed the technology from NASA and plans to market it in the form of a software product for home, professional and industrial use by the end of the year.

With this technology, amateur photographers armed with nothing more than their personal computers and a desire to get the most from the images they capture will have the ability to increase the brightness, scene contrast, detail and overall sharpness of images with much more ease than they can today.

What distinguishes this technology from existing image-enhancement technologies is that it makes corrections automatically, yet allows the end-user to manipulate the image as desired. As a result, the average photographer is more likely to use the technology and use it successfully.

It won't correct every image, but it was impressive enough to win a NASA Space Act Award as one of the space agency's top inventions of the year for 1999.

"What makes Retinex technology so valuable is that every image can stand a little improving, especially dark, low-contrast images," said Glenn Woodell of NASA Langley, one of three inventors of the technology.

Dan Jobson, also of Langley and the technology's principal investigator, teamed with co-inventors Woodell and Zia-ur Rahman of STC to modify the technology for commercial applications.

"STC thinks consumers will find this technology so easy and gratifying to use that people who would never consider doing anything more than snapping a picture will let Retinex finish the job," said Rahman.

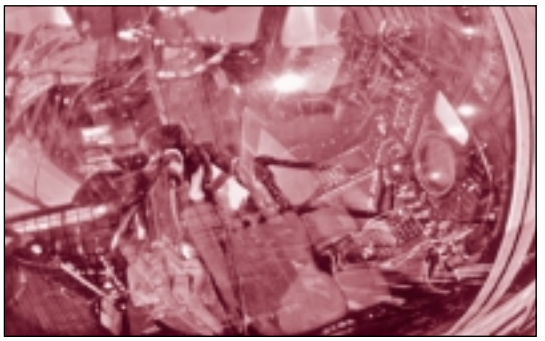
The realistic beauty and visual impact of photographs can be diminished, damaged or ruined by a variety of possible problems. For example, colors and details can be lost or suppressed in shadows or other low-light level zones in a picture. These same scenes, when viewed directly by the human observer, are vivid by comparison to the recorded image. Consequently, the user loses both the visual quality and emotional intensity of that captured memory.

"Existing image enhancement methods used to correct these limitations are either insufficiently powerful or require tedious and extensive manual user interactions," said Marisol Garcia, Langley's Retinex commercialization project manager.

Not only is this technology useful for improving consumer images, but it has been successfully applied to medical images as well. It has performed very well with x-rays, such as in mammograms and dental panoramas, and in other applications such as photographs of the retina.

The technology is currently being refined for video image enhancement, where the technology's high-speed, automatic correcting features should make quick work of an otherwise tedious and extensive process.

For more information, contact Glenn Woodell at NASA Langley Research Center, ✉ *g.a.woodell@larc.nasa.gov.* Please mention you read about it in *Innovation.*



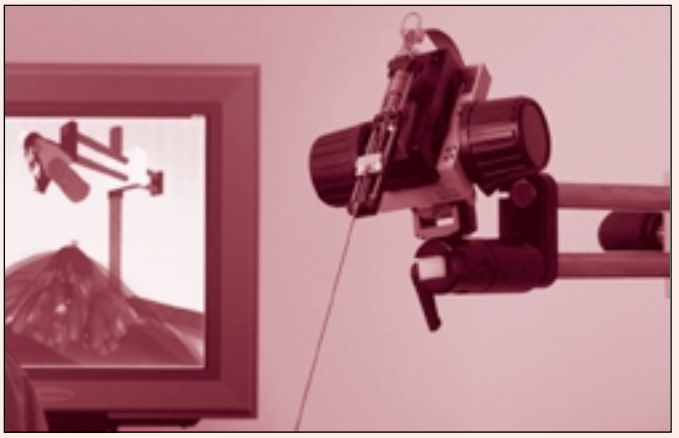
In the image on the left, before Retinex Imaging Processing, detail inside the cockpit is lost due to hazing from the canopy reflections. In the photo on the right, after Retinex Imaging Processing, detail is dramatically visible.

TECH BOX: SMART SURGICAL PROBE TO BEGIN CLINICAL TESTS

A revolutionary early breast-cancer-detection tool based on NASA technology began human clinical trials in November after receiving the go-ahead from the Food and Drug Administration.

Dublin, California-based BioLuminate Inc., the start-up company licensed by NASA to develop, produce and market the Smart Surgical Probe, began human testing on volunteer patients at the University of California (UC) Medical Center in Davis and at the University of California, San Francisco (UCSF). The Smart Surgical Probe was originally developed by Dr. Robert Mah at NASA's Ames Research Center in Moffett Field, California.

"This device is being developed to make real-time, detailed interpretations of breast tissue at the tip of the needle," said Mah. "The instrument may allow healthcare providers to make expert, accurate diagnoses, as well as to suggest proper, individualized treatment, even for patients in remote areas," he said. The probe is a small, disposable needle with multiple sensors. This technology and resulting product may enable physicians to diagnose tumors without surgery, thereby dramatically reducing the number of unnecessary breast biopsies women undergo annually.



The cancer smart probe with an animation picture of it on the computer monitor in the background. The probe is in the early stages of clinical trials. Photo provided by Ames Research Center.

Smart Probe's sensors begin gathering information the moment the needle is inserted into tissue. Computer software eventually will compare the real-time measurements to a set of known, archived parameters that indicate the presence or absence of cancer, and display the results on a computer screen.

More than 200 patients scheduled for a surgical biopsy were invited to volunteer to be tested with the Smart Probe prior to their medical procedure. Recorded data then will be used to "teach" the probe to distinguish cancerous tissue from benign.

"With the knowledge gained from this study, we will be able to develop the first commercial prototype. That prototype will be used in our next clinical study, which will involve nearly 10,000 women," said BioLuminate president and CEO Richard Hular. "The data we acquire each time the needle is inserted into a suspicious lesion later confirmed to be cancerous enables us to teach the computer to become more accurate and recognize cancerous tissue on its own."

Every week in the United States approximately 18,000 surgical breast biopsies are performed on women with suspicious breast lesions that later are determined to be benign. By taking the Ames Smart Probe and developing it further in collaboration with the Lawrence Livermore National Laboratory in Livermore, California, BioLuminate hopes to produce a real-time measurement instrument that will reduce the need for unnecessary surgery. "If we are successful, the probe will significantly improve women's healthcare and could potentially reduce annual healthcare costs," said Hular.

"With BioLuminate, we have taken the multi-sensor NASA concept, selected new optical sensor technology and packaged it into a thin needle-sized instrument that can pinpoint whether a tumor in the breast is cancerous or benign," said John Marion, Lawrence Livermore National Laboratory's principle investigator for the Smart Probe.

"The BioLuminate needle offers the potential to improve localization of cancer tissue, eliminate removal of tissue and the associated complications, and, most importantly, obtain more accurate information for diagnosis," said Lydia Howell, MD, director of cytology and professor of pathology at UC Davis. "The information obtained by the needle also has the potential to be useful in predicting how a cancer may behave.

The needle may be able to not only distinguish benign lumps from cancerous lumps, but also to distinguish which cancers are more aggressive so the patient can receive stronger therapies."

"This is an exciting technology that has immediate and future promise to improve the treatment of breast cancer," said Laura Esserman, MD, MBA, director of the Carol Franc Buck Breast Care Center at the UCSF Comprehensive Cancer Center. "I also am excited by the possibility that this technology would help us to evaluate the presence of residual disease at the time of surgical excision, thereby reducing the need for additional surgery for women who are being treated using breast conservation."

"The commercialization of this NASA technology is an outstanding example of applying space research technology to bring healthcare benefits down to Earth," noted Phil Herlth, of the Ames Commercial Technology Office.

For more information, contact Michael Braukus at NASA Headquarters, 202/358-1979, *mbraukus@mail.hq.nasa.gov* or Victoria Kushnir at NASA Ames Research Center, *vkushnir@mail.arc.nasa.gov*. Please mention you read about it in *Innovation*.

NASA and Stanford Form Biocomputing Collaboration

UNDER A POWERFUL NEW PARTNERSHIP agreement, joint research efforts at NASA and Stanford will benefit from computational technologies that have led to recent breakthroughs, such as understanding the genetic basis of diseases.

NASA's Center for Computational Astrobiology and Fundamental Biology (NCCAFB), based at NASA's Ames Research Center, and Stanford's Center for Biomedical Computation (CBMC), recently announced a collaborative partnership to conduct multi-disciplinary research and development in the emerging field of computational biology. The goal of the collaboration is to develop new methods of computational biology and apply them to explain how cells function, evolve and are affected by diseases, both on Earth and in space. Computational biology is an emerging interdisciplinary field that uses computers and specialized software to solve biological problems and apply the solutions to diverse applications in biology, medicine and space science.

"This collaboration will greatly enhance NASA's research process in astrobiology and the related field of space genetics," said Dr. Andrew Pohorille, director of the NCCAFB at Ames Research Center in the Silicon Valley. "It is a unique partnership because we will use new computational methods developed at Stanford and at Ames to interpret the data both from Stanford's laboratory experiments and from experiments in space."

One early joint effort will be to apply the tools of biomedical computing to NASA's space genetics program, said Pohorille. Space genetics aims to characterize the structural, genetic and protein "footprints" (or signatures) inside cells, tissues and organisms in space. NASA will first test human kidney cells flown on the International Space Station. Unlike conventional cells grown in laboratories on Earth, kidney cells flown in space closely mimic how cells actually interact inside a human body. Good tissue models will greatly aid researchers in finding cures for kidney diseases.

The collaboration also is unique because it will employ NASA's state-of-the-art supercomputers, taking advantage of Ames' role as NASA's lead center in information technology. The NCCAFB currently uses nearly 4,000 processors on SGI supercomputers at the NASA Advanced Supercomputing Division at Ames.

"We are excited that this joint effort will exploit our mutual synergies and accelerate progress in the vital new area of computational biology," said Dr. Russ B. Altman, director of the CBMC at Stanford. Stanford initially intends to focus on three projects: the integration of diverse databases, the simulation of physical models and the development of methods for smoothly moving between images and their corresponding physical models. "These projects are part of a grant we received in October from the National Institutes of Health (NIH) that will kick-start the center and prepare Stanford for a larger set of projects in the future," Altman said.

Computational biology has become indispensable in modern biology because it lets scientists gather, store and analyze vast amounts of data obtained from gene sequencing, the use of micro-arrays and the study of proteins and cell physiology. Computational biology has already led to breakthroughs in identifying and testing for genetic diseases, for example.

Initial collaborative research will focus on cell metabolism, using both healthy and diseased cells cultured from experiments on Earth and in space. In addition, the partnership will develop new information management tools to use on NCCAFB's massively parallel computers.

"This is just the first step," Pohorille said. "The grand vision of the partnership is to create a nucleus for a broad, regional partnership that will eventually include academia, national laboratories and industry."

For more information, contact Phil Herlth at NASA Ames Research Center, ✉ *pherlth@mail.arc.nasa.gov*. Please mention you read about it in *Innovation*.

Composite Tank Passes Proof Tests

A JOINT EFFORT BETWEEN NASA AND LOCKheed Martin has resulted in the development and successful initial testing of the first subscale cryogenic tank built of a composite material that is compatible with liquid oxygen. Lockheed Martin designed and built the composite tank, and NASA is testing it at the Marshall Space Flight Center (MSFC) in Huntsville, Alabama.

The tank has successfully completed the initial cycles of cryogenic, or very low temperature, proof testing in liquid oxygen. In testing, the tank is enduring thermal and pressure environments that simulate the flight conditions a liquid oxygen tank would expe-

Engineers, at the Marshall Space Flight Center, Huntsville, Alabama, prepare a composite liquid oxygen tank for testing. The tank was designed and built by Lockheed Martin. Photo provided by Marshall Space Flight Center.

rience on a space launch vehicle. The tank also will undergo lifecycle testing at MSFC to demonstrate mission life capabilities.

"This marks a real advance in space technology," said Michael Phipps, NASA project manager for this material characteristics development unit. "No approved standards for composite pressure vessels exist; there has not been enough information on them to write standards. So the technical data we are getting from this effort is very valuable."

Using state-of-the-art cryogenic composite tank analysis, fabrication and inspection techniques, the Lockheed Martin/NASA team designed and constructed the tank at both MSFC and the NASA Michoud Assembly Facility in New Orleans, Louisiana. The composite tank is approximately nine feet (2.7 meters) in length and four feet (1.2 meters) in diameter, and weighs less than 500 pounds (225 kilograms), which represents an 18 percent weight savings over a metal tank of similar construction.

Composites are seen as one of the key components in the drive by NASA and the aerospace industry to decrease the weight of future launch vehicles as a means of reducing the cost of launching payloads into orbit from the current $10,000 per pound to $1,000 per pound.

That is one of the goals of NASA's second-generation Reusable Launch Vehicle (RLV) program—a research and technology development effort that also aims to substantially improve safety and reliability. MSFC manages this program for NASA.

For more information, contact Michael Phipps at Marshall Space Flight Center, 256/544-0828, *michael.Phipps@msfc.nasa.gov*. Please mention you read about it in *Innovation*.

NASA Reduces Wildfire Response Time

US FIREFIGHTERS AND LAND MANAGERS ARE using the most modern NASA satellite data to combat wildfires. NASA's Terra satellite provides a view of fires across all of the conterminous United States, which helps manage fires more effectively, both during and after wildfire events. The effort is a collaboration between NASA, the University of Maryland and the USDA Forest Service.

The Terra satellite beams daily images of western US wildfires to NASA within a few hours of the time that it passes over the region. These images and active fire detections are transmitted to the US Forest Service (USFS). Images from Terra's Moderate Resolution Imaging Spectroradiometer (MODIS) will become a regular part of the Forest Service's fire-monitoring toolkit.

In order to use MODIS data to tackle forest fires, a complex communications network must be maintained between NASA, the University of Maryland and the USDA Forest Service. The three institutions are all integrated under the Rapid Response Project. Rob Sohlberg, at the University of Maryland's department of geography in College Park, Maryland, leads the Rapid Response Project with Jacques Descloitres at NASA's Goddard Space Flight Center in Greenbelt, Maryland. This program was created in response to a very bad fire season in 2000, including extensive wildfires in Idaho and Montana.

"The Active Fire Maps offer the potential for understanding the "big picture" when working on resource allocations decisions," said Alice Forbes, deputy director for Forest Service Fire and Aviation Operations at the National Interagency Fire Center (NIFC). "The maps also can help the public understand where the fires are located and give them a look at the burned areas after fire season."

The University and NASA have developed all of the needed software, which will be installed at the USFS direct broadcast station. The USFS has developed the corresponding software that creates the maps from the Terra data using standard USFS mapping techniques.

The USDA Forest Service Remote-Sensing Applications Center (RSAC), in Salt Lake City, Utah, provides development, support and application of remote-sensing technologies and techniques. Currently, the Forest Service is building a MODIS processing center in Salt Lake City to generate real-time images of western wildfires. However, the Forest Service will still receive imagery of the eastern US from the University and NASA.

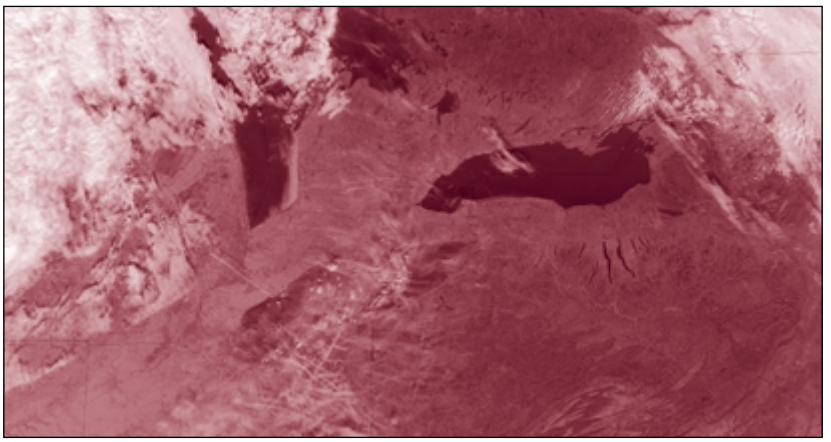
Keith Lannom, the operations program leader at RSAC, stated "the University of Maryland sends MODIS images and active fire location information daily to RSAC staff who are overlaying state bound-

aries and topographical features on the images to best determine where fires are occurring. These maps show active fire areas in real-time on the Internet."

The maps also show areas that were burned during previous days. These maps will be used for strategic asset allocation when fighting wildfires. Advanced products to assist the Burned-Area Emergency Rehabilitation (BAER) teams are being developed from Terra data. The BAER team consists of soil scientists, hydrologists, wildlife specialists and other scientists. They use burn severity maps—derived from satellite and ground measurements—to take measures that will prevent further erosion, soil loss and adverse impacts to water quality. It is anticipated that Terra data will provide a quick look, which can then be refined on the ground. The maps will also help scientists identify critical wildlife habitat affected by the fire and facilitate reforesting an area.

Wei Min Hao, the project leader of the Fire Chemistry Project at the Forest Service's Fire Science Laboratory in Montana, is developing a MODIS aerosol product to track smoke dispersed by wildfires and to determine the impact on regional air quality. Hao said, "during fires where there are large amounts of smoke, reconnaissance planes that normally map fires can't fly into an area, but MODIS can provide those pictures from space." Dr. Yoram Kaufman, from NASA, is working with Dr. Hao on these products.

The Terra spacecraft is part of NASA's Earth Science Enterprise, a long-term research effort being conducted to determine how human-induced and natural changes affect our global environment.



The view from NASA's Terra satellite of wildfires in the Appalachian Mountains of the eastern United States. Photo provided by Goddard Space Flight Center.

For more information, contact Jacques Descloitres, ✉ *jack@ltpmail.gsfc.nasa.gov,* or go to the Web site *http://rapidfire.sci.gsfc.nasa.gov.* Please mention you read about it in *Innovation*.

R&D 100 AWARDS RECOGNIZE HILBERT HUANG TRANSFORM

For 39 years, the R&D 100 Awards program has recognized the developers of the top 100 technologically significant products introduced into the marketplace over the past year. This year the Hilbert Huang Transform (HHT), developed by Norden Huang of the NASA Goddard Space Flight Center in Greenbelt, Maryland, was selected for this prestigious award.

HHT is also known as the Empirical Mode Decomposition (EMD) method. This technique decomposes a complicated set of data into a finite, smaller number of functions. The smaller functions are oscillation modes or vibrations contained in the original data and are associated with the time scale of the data. The Hilbert Transform creates an energy-frequency-time distribution of these decomposed data.

HHT is groundbreaking because it produces more precise, meaningful and interpretable results of nonlinear and non-stationary data. Nonlinear data for events ranging from earthquakes to heart arrhythmias have long been analyzed, but their underlying phenomena had to be frozen in time and space. HHT is the first adaptive method for measuring things that don't stay still and don't follow regular patterns. The result is a more precise definition of particular events in time-frequency space and a more meaningful interpretation of underlying dynamic processes than can be obtained with historical methods.

Dr. Norden Huang of Goddard Space Flight Center, developer of the Hilbert Huang Transform, which was selected as a winner of the 2001 R&D 100 Awards. Photo provided by Goddard Space Flight Center.

For more information, contact Evette Conwell at Goddard Space Flight Center, ✆ 301/286-0561, ✉ *Evette.Conwell@gsfc.nasa.gov.* Please mention you read about it in *Innovation*.

Computer Tool Smoothes Air Traffic Flow

AIR TRAFFIC CONTROLLERS WILL BE ABLE TO make decisions about air traffic with greater accuracy thanks to a new NASA software tool.

Researchers at NASA's Ames Research Center, located in California's Silicon Valley, recently monitored more than 1,000 take-offs, landings and overhead flights near Denver to test the en-route data exchange (EDX) tool. The tool allows for the real-time delivery of flight data to automated air traffic management software, giving controllers the ability to predict aircraft position and avoid potential conflicts.

"The ability to accurately predict aircraft trajectories more than 20 minutes in advance is crucial to the success of air traffic management," according to Rich Coppenbarger, EDX technical lead. "EDX allows automation used for air traffic control decisions to be more accurate, thereby increasing fuel efficiency and system capacity, and reducing controller workload," he added.

EDX delivers 32 types of data from the plane to air traffic controllers who are using NASA's Center-TRACON (Terminal Radar Approach Control) Automation System, or CTAS. Some data, including aircraft speed, weight, flight plans and weather conditions, are processed immediately, and the rest are stored for later analysis.

"Field experience has shown that controllers must have confidence in the accuracy of underlying trajectory predictions in order to utilize our automation effectively. EDX provides that level of trust by providing a wealth of accurate and timely data," said Coppenbarger.

With cooperation from United Airlines, 48 Boeing 777 aircraft received EDX software upgrades. The 777 was chosen because of its state-of-the-art avionics and advanced handling of "datalink" information.

The six-month test of EDX was conducted at the Denver Air-Route Traffic Control Center with the assistance of the Federal Aviation Administration (FAA), Washington, DC; Honeywell, Morristown, NJ; and United Airlines, Chicago.

The next step is evaluation of the tool's capabilities for future application to real-time flight plan development and modification. This capability can be viewed as an important step toward attaining Free Flight, which is an FAA program that will give pilots the freedom to choose their own flight paths in real-time.

THE TOOLS WITHIN THE CTAS SUITE ARE DESIGNED TO HELP AIR TRAFFIC CONTROLLERS MANAGE THE INCREASINGLY COMPLEX AIR TRAFFIC FLOWS AT LARGE AIRPORTS AND EN ROUTE. THE TOOLS IN CTAS BENEFIT AIR TRAVELERS BY REDUCING DELAYS WHILE MAINTAINING SAFETY.

The tools within the CTAS suite are designed to help air traffic controllers manage the increasingly complex air traffic flows while en route at large airports. The tools in CTAS benefit air travelers by reducing delays while maintaining safety.

EDX is being developed under the Advanced Air Transportation Technologies (AATT) project, a part of NASA's Aviation Systems Capacity Program led by Ames Research Center. Ames has been conducting air traffic control research and development since the mid-1980s.

For more information, contact Cathy Pochel at NASA Ames Research Center, 650/604-4595, cpochel@mail.arc.nasa.gov, 650/604-1592.
Please mention you read about it in *Innovation*.

Flying Laboratory Takes Synthetic Safety Tour

NASA RESEARCHERS ARE TESTING A REVOLUTIONARY cockpit technology that will help pilots avoid deadly accidents caused by poor visibility. A passenger jet equipped with futuristic, three-dimensional computer displays has been flown over the Rocky Mountains not far from Vail, Colorado.

Engineers from NASA's Langley Research Center in Hampton, Virginia loaded a computer database depicting Vail's mountainous terrain on board a

NASA research aircraft known as ARIES or Airborne Research Integrated Experiments System.

ARIES is a highly modified Boeing 757 passenger jet transformed into a "flying simulator."

The ARIES aircraft took off from the Colorado Springs Airport and made a number of flights over the Eagle County Regional Airport in support of the NASA Aviation Safety Program's (AvSP) Synthetic Vision Systems project. The NASA AvSP is working with industry teams to create and refine Synthetic Vision, a revolutionary display system for cockpits that will offer pilots an electronic picture of what is outside their windows, no matter what the weather is like or the time of day.

During the three weeks of flights, pilots from NASA, Boeing, the Federal Aviation Administration (FAA) and major airlines tested various Synthetic Vision display concepts in a real-life, difficult terrain environment. They evaluated display sizes, fields of view and computer graphic options to help determine which configurations will be most effective in preventing accidents. The system includes visual cues that will give pilots precision navigation guidance and help them to avoid obstacles.

Limited visibility is one of the greatest factors in most fatal aircraft accidents, according to Michael Lewis, director of the NASA Aviation Safety Program, headquartered at Langley. "With Global Positioning Satellite signals, pilots now can know exactly where they are," said Lewis. "Add super-accurate terrain databases and graphical displays, and we can draw three-dimensional moving scenes that will show pilots exactly what is outside. The types of accidents that happen in poor visibility just don't happen when pilots can see the terrain hazards ahead."

The NASA Aviation Safety Program envisions a system that will use new and existing technologies to incorporate data into displays in aircraft cockpits. The displays will show terrain, ground obstacles, air traffic, landing and approach patterns, runway surfaces and other relevant data to the flight crew.

The NASA Aviation Safety Program is a partnership with the FAA, the Department of Defense, aircraft manufacturers, airlines and universities. This partnership supports a national goal of reducing the fatal aircraft accident rate by 80 percent in 10 years.

Researchers at four NASA field installations are working with the FAA and industry to develop advanced, affordable technologies to make flying safer. These centers include Langley Research Center in Hampton, Virginia; Ames Research Center in Moffett Field, California; Dryden Flight Research Center in Edwards, California; and Glenn Research Center in Cleveland, Ohio.

For more information, contact Michael Braukus at NASA Headquarters, 202/358-1979, *mbraukus@mail.hq.nasa.gov*. Please mention you read about it in *Innovation*.

Hand-Held Computers May Reduce Airport Congestion

NASA RESEARCHERS HAVE FOUND THAT small, Internet-linked computers in the hands of airport workers may help unclog the nation's airport terminals.

NASA scientists at Ames Research Center in Moffett Field, California collaborated with United Airlines on a two-year project. Researchers suggest that additional "curb-to-gate" changes, including better signs in terminals, synchronized clocks and improved check-in procedures, as well as improvements in airline and airport operations, may help reduce flight delays.

"The study recommends the development of a next generation of airport information systems. These would include the use of hand-held computers to allow airline employees and others to update schedules on the tarmac, on baggage carts and in gate areas," according to Roxana Wales, PhD, a member of the Ames research team. "Delays can arise at any point in a flight, including preparations before leaving the gate; and difficulties at one point can lead to a slipped schedule at any other point."

"We have to focus on the entire system. Much of the current attention focuses on the movement of planes instead of the whole process of getting people from point A to point B."

Other experts across the country have advocated adding runways to airports and are working to improve air traffic control systems.

"Airline and airport operations need to be included in the debate of how to streamline the nation's air travel system," said Wales.

"United Airlines allowed us access to non-public areas and to interact and talk with employees at all

levels. This is extraordinary access for a group of researchers," she explained.

The team conducted extensive research in airline operation centers, on baggage ramps where airplanes are loaded and unloaded, in airline lobbies, at counters, at passenger gates and in control towers.

Today's airport information and communication systems are designed for routine aircraft turnaround, according to the NASA research team. Problem and delay situations "require a richer information environment to facilitate decision-making," Wales said.

The good news is that there are near-term solutions in sight that include simply integrating information systems across groups in airports, according to the NASA researchers. They also said

SOLAR AIRCRAFT SETS ALTITUDE RECORD

The unique Helios Prototype solar-powered flying wing, developed by AeroVironment, Inc. for a NASA program managed by Dryden, reached an altitude of 96,863 feet during a maximum-altitude flight on August 13 from the US Navy's Pacific Missile Range Facility (PMRF) on the Hawaiian island of Kauai.

Although short of the 100,000-foot altitude that project officials hoped for, the altitude is the highest ever flown by a non-rocket-powered aircraft in sustained horizontal flight and well above the current world altitude record of 85,068 feet for sustained horizontal flight by an aircraft, set by a US Air Force Lockheed SR-71A reconnaissance aircraft in July 1976. It also surpassed the existing altitude record for propeller-driven aircraft, 80,201 feet, set by the Helios Prototype's predecessor, the Pathfinder-Plus, in August 1998. The 96,863-foot record altitude remains unofficial, however, until certified by the National Aeronautics Association's Board of Records and Standards.

"This is like going to the Olympics and setting a new world record for engineers," added John Del Frate, solar aircraft project manager at Dryden. "This achievement did not come easily. Thousands of things had to work right for something like this to come together."

Due to shortening hours of daylight, a reduced sun angle as the summer waned in the northern hemisphere and low cloud cover during the morning, which delayed take-off by about 36 minutes, the Helios Prototype's time-to-climb was limited to about seven hours. The aircraft reached its maximum altitude shortly after 4:00 PM, when the sun angle had already dropped to less than 45 degrees, and Helios' climb rate dropped to zero. Even with the reduced angle, however, the solar arrays atop the Helios' wing were still producing about 24 kilowatts, or about 70 percent of their maximum rated output of 35 kilowatts at mid-day.

The Helios Prototype flew for more than 40 minutes above a 96,000-foot altitude before beginning its descent. It was in the air for almost 17 hours on the record flight, having lifted off the PMRF runway at 8:48 AM and landed at 1:43 AM the following morning after a 9 1/2-hour descent. Electrical power for post-sunset flight was provided by the generating capability of the motors using the windmill effects of the propellers as the aircraft glided down.

Project officials report that Helios' propulsion, avionics, environmental and flight control systems worked flawlessly during the flight. Temperatures encountered ranged from 80° F at take-off to a low of minus 85° F at 58,000 feet, but all systems stayed within their temperature limits.

The remotely operated aircraft had reached 76,200 feet during its first checkout flight from PMRF under solar power a month earlier on Saturday, July 14. The Helios Prototype flew six low-altitude airworthiness validation flights on battery power at Dryden in the fall of 1999.

Since then, the aircraft underwent major upgrades, including the installation of high-efficiency solar cell arrays across the wing, navigation and emergency lights, and improved avionics. AeroVironment technicians also completed upgrades to the ground control station and the tracking antennas, and updated operational procedures. More recently, AeroVironment developed a new propeller design that is both stronger and more efficient than the propellers that drove the Helios Prototype during its earlier test flights. The new propellers were used on both the record flight in August and the earlier checkout flight in July.

The maximum-altitude flight was one of two major flight milestones set for the craft by NASA—the other being a four-day non-stop endurance demonstration flight above 50,000 feet planned for 2003. Development of a regenerative hydrogen-oxygen energy storage system that would make the multi-day continuous flight possible is progressing at AeroVironment. The system will use excess power generated by the solar arrays during the daytime to run an electrolyzer

that better communications and other improvements should include not only airline employees, but all workers involved in smoothly getting a passenger from the street to his or her destination.

"A breakdown in the process, where the customer is unable to understand and expediently move through one step to another, at any point, can contribute to a delay," said Zara Mirmalek, research team member. The team conducted research at San Francisco's United domestic terminal and airports serving Atlanta, Chicago and Oakland, California.

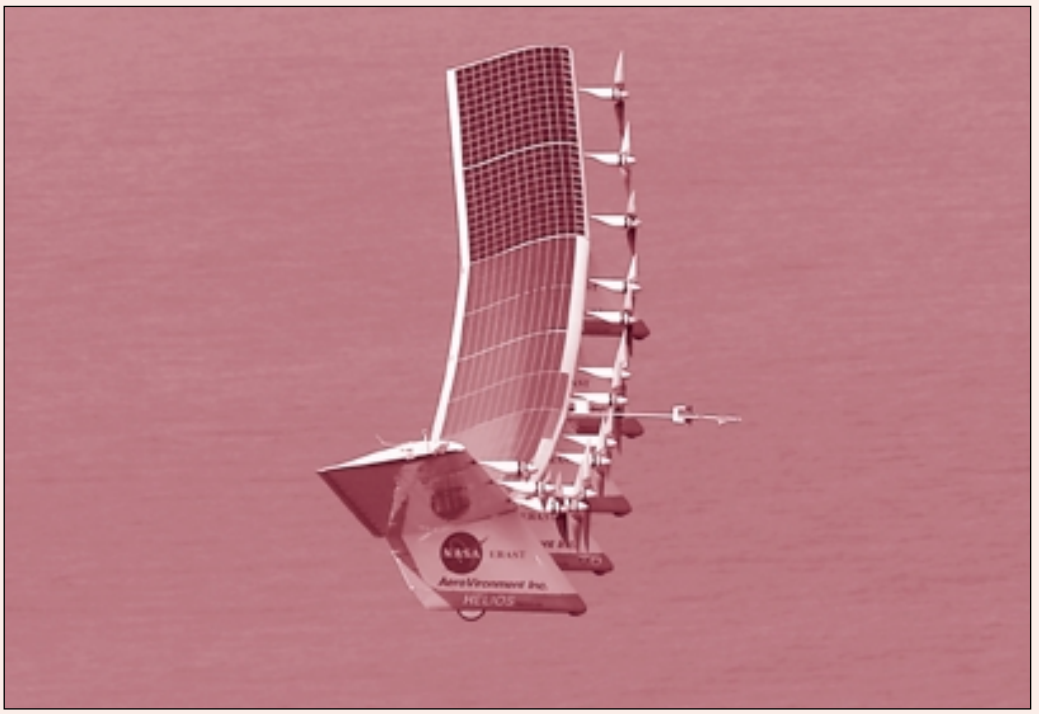
For more information, contact Michael Braukus at NASA Headquarters, 202/358-1979, *mbraukus@hq.nasa.gov* or Roxana Wales, PhD, NASA Ames Research Center, *rwales@mail.arc.nasa.gov*. Please mention you read about it in *Innovation*.

that separates water into its component parts, hydrogen and oxygen, which are then stored under pressure in specially designed tanks. At night, the hydrogen and oxygen will be recombined by the fuel cells, producing electricity as a by-product to power Helios' motors and systems.

Production variants of Helios might see service as long-term Earth environmental monitors, disaster monitoring, as well as communications relays, reducing dependence on satellites and providing service in areas not covered by satellites. The record-altitude flight also provided NASA and AeroVironment with information on how an aircraft would fly in a Mars-like atmospheric condition, since the atmosphere at that altitude above the Earth is similar to the atmosphere near the Martian surface.

The 247-foot-span ultra-light flying wing's development is being funded and managed under NASA's Environmental Research Aircraft and Sensor Technology (ERAST) project.

For more information, contact John Del Frate at NASA Dryden Flight Research Center, 661/276-3704, *John.DelFrate@dfrc.nasa.gov* Please mention you read about it in *Innovation*.



The Helios Prototype aircraft in the early stages of its record-breaking high-altitude flight. Photo provided by Dryden Flight Research Center.

SBIR-Produced Converter Provides Thrust

ANOTHER STEP TOWARD LONGER, SPEEDIER deep-space missions was taken when an SBIR-produced Stirling converter provided the electricity to a Hall effect electric thruster in recently completed tests at the NASA Glenn Research Center, Cleveland, Ohio. Together, the two technologies, which had never before been operated as an integrated system, signal the arrival of lower mass, higher efficiency propulsion for NASA's deep-space missions.

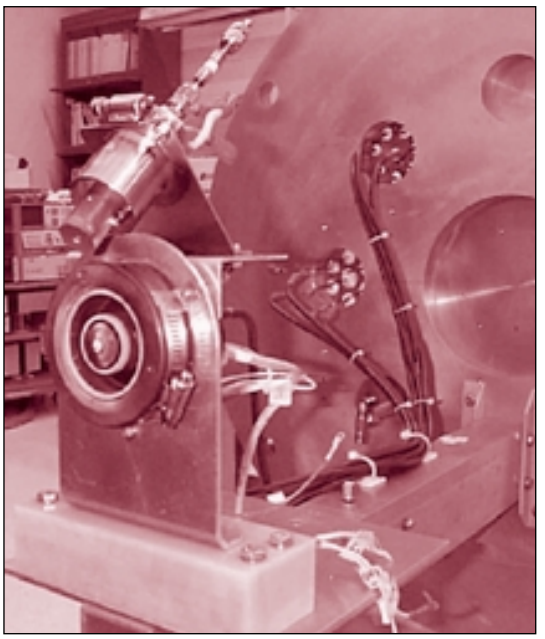
"Both of these technologies are now at a development level that allows them to be considered by NASA mission planners. Since Glenn has long been involved in developing these concepts into space technologies, the idea of putting them together was a natural for us," said Glenn project engineer Lee Mason. "We broke new ground with this test in that we established the feasibility of this system."

The 350-watt Stirling converter was built by Stirling Technology Co., of Kennewick, Washington, under an SBIR agreement with Glenn. The Hall effect electric thruster was chosen to match the Stirling converter's output from Glenn's inventory of such thrusters. Glenn researchers designed the power processor unit that took the electrical output from the converter and distributed it to all the loads of the thruster.

A Stirling converter changes heat energy into electricity through the action of an expanding fluid that drives a piston through an alternator's magnetic field. An electric thruster uses electricity to ionize (or strip an electron from) its propellant, which produces thrust on ejection from the thruster.

Fitted with a nuclear heat source, Stirling converters become strong candidates for providing electrical power for robotic missions to the outer solar system, where solar panels would be ineffective. Their potential for high-power output also makes them attractive in any type of mission with power-hungry systems like electric thrusters.

Electric thrusters produce much less thrust but are up to 10 times more fuel-efficient than chemical rockets. Because of this, the spacecraft they propel can be smaller and lighter, costing much less to launch. Despite their miniscule thrust, electric thrusters can make longer trips in shorter times, as they can operate continually and fly directly to their destinations without the circuitous gravity-assist maneuvers that chemical rockets often require.



A Stirling converter (top) provided the electricity to a Hall effect electric thruster (bottom) in tests at Glenn Research Center. Together, the technologies signal the arrival of lower mass, higher efficiency propulsion for NASA's deep-space missions. Photo provided by Glenn Research Center.

The next development goal, according to Mason, is to increase the efficiency of the power transfer. "A direct drive system, eliminating the power processor unit, would increase efficiency and reduce mass, making the technology even more attractive," Mason concluded.

For more information, contact Lee Mason at NASA Glenn Research Center, 216/977-7106, *Lee.S.Mason@grc.nasa.gov*. Please mention you read about it in *Innovation*.

Three-Dimensional Displays Available

DIMENSION TECHNOLOGIES INC. (DTI) IS THE world's only manufacturer of commercially available two-dimensional/three-dimensional (2D/3D) switchable Liquid Crystal Displays (LCD) and owns many of the world's major patents on the technology. These unique 15- and 18.1-inch flat panel displays are in use around the world in hundreds of design, research, medical imaging, education and industrial applications.

Current users include Goodyear, Microsoft, Northrop Grumman, Lockheed, Alias/Wavefront, Ford, Canon, Chrysler, Honeywell, Apple, nVidia, Intel, Telesat Canada, NASA, all branches of the military, Johns Hopkins, National Institutes of Health, Idaho National Energy Lab, Naval Research Lab, Sandia Lab and more. University users include MIT, Stanford, Rochester Institute of Technology, Cambridge and the University of Arizona. Museum users include the Technical Museum of Innovation, the Space and Science Institute, and the Getty Museum.

Images on these unique displays appear to leap off the screen and hang in space or recede into the background. These displays accept input from computers or stereo video sources, and can be switched from 3D to full-resolution 2D viewing with the push of a button. DTI 2D/3D displays provide an effective, economical complement to glasses-based 3D systems and are particularly applicable for extended use environments. The smaller size and lower energy requirements will also be attractive to 3D users.

Much of the company's current success and growth can be attributed to very early research funding by NASA. In 1990, not long after DTI was established, the agency was looking for a way to enhance its understanding of great masses of data like those for fluid flow around space shuttle launches. It believed that a 3D presentation of this information would aid in its interpretation. NASA contracted the company through its SBIR program to further develop DTI's then-crude 3D display.

That early funding has led to the current family of Virtual Window™ LCD 3D displays. The technology is readily adaptable to flat panel displays of all sizes and types, and DTI has an active licensing program for manufacturers who wish to add 3D capability to their display products.

A computer monitor capable of both two- and three-dimensional display. Three-dimensional displays are potentially useful in telemedicine and surgical simulators, among other applications. Photo provided by Glenn Research Center.

An example of application for this unique imaging technology is telemedicine and surgical simulations, both in space and on the ground. Surgical simulators allow virtually unlimited practice with open surgical techniques, making surgical residencies more efficient and effective. Simulators can allow non-surgeon scientists in space to rapidly practice surgical procedures in the event that someone has to fill in for the onboard doctor. This concept can also be extended to many areas on Earth, where funding constraints often minimize the experience of physicians and preclude the availability of state-of-the-art equipment.

While surgical simulators using 3D displays and workstations are now projected to cost nearly $100,000, new software and the availability of more powerful desktop PCs will drive costs down fairly quickly, making them more widely available.

The basic technology has been reduced to a single active substrate that inserts between the LCD and its backlighter. When turned on, it allows the display to show real 3D images by creating light lines. These light lines are placed behind a conventional LCD panel—the exact sort of LCD panel that is so common on laptop computers, desktop displays, personal digital assistants, cell phones and many other devices.

The observer sees the light lines through the columns of pixels on the LCD. Left-eye and right-eye views of the same scene are interleaved on the LCD pixel columns when in 3D mode. Each eye sees the scene from a slightly different angle—just as we do in real life because our eyes are spaced slightly apart. This slight angular displacement is what causes the 3D effect, both in real life and in our display. When the

active substrate is turned off, the 3D effect disappears. The image on the LCD display then appears in 2D, just as it does on current laptop computers and PDAs.

This ability to convert instantly from 3D to 2D display is the characteristic that makes DTI displays unique in the world. No other 3D display converts to full-resolution 2D. A single DTI flat panel can fulfill the normal desktop display requirements—word processing, spreadsheets, e-mail/Internet, etc.—and then instantly be switched to 3D display mode for design, research and education applications, saving the cost, size and energy requirements of a second display.

DTI 3D LCD displays are beginning to appear in commercial settings in small quantities. As the technology develops ever more rapidly, most technology watchers are predicting that flat panel-based consumer products will have 3D capability fairly soon. Most companies with flat panels in their product lines already have the volume required to drive the incremental cost of this technology to near 2D-only price. It is a very short jump technologically from surgical simulators to 3D computer and laptop displays, flat panel 3D television and merchandising displays in malls and showrooms—all with pictures that jump off the screen and "bite you on the end of your nose."

For more information, contact Arnold D. Lagergren, president of Dimension Technologies Inc., 315 Mt. Read Blvd., Rochester, NY 14611, *www.dti3d.com*, 716/436-3530, *adl@dti3d.com*. Please mention you read about it in *Innovation*.

NASA SBIR COMPANIES EARN TIBBETTS AWARDS

On October 2, 2001, representatives from small businesses, business assistance organizations and government officials from around the country met in Washington, DC for the annual Tibbetts Award ceremonies.

The Tibbetts Awards are named for Roland Tibbetts, who is widely acknowledged as the "father" of the Small Business Innovation Research Program (SBIR). The award was established to give national and well-deserved recognition to the small businesses and SBIR support organizations that exemplify the types of business, economic and technical development goals of the SBIR program.

NASA is extremely proud of many of the companies that participate in its SBIR program and is happy to announce that many of the 2001 Tibbetts winners have a relationship with NASA. The following are winners who have worked extensively with NASA:

Cox and Company, of New York, has developed an economical anti-icing system for general aviation aircraft. This system received FAA certification in May 2001 and is the first "new" ice-protection system to be certified in 40 years.

Sierra Lobo, Inc., headquartered in Fremont, Ohio, is a leader in cryogenic densification and has developed a Densified Propellant Management System that may help NASA save millions of dollars in launch costs.

Sensors Unlimited, Inc., located in Princeton, New Jersey, is a leading supplier of semiconductor diode lasers in the near-infrared range. Specifically for NASA, Sensors Unlimited has produced lasers that will support NASA's miniature lidar instrument for remote sensing of the surface of Mars.

Aeptec Microsystems, Inc., of Rockville, Maryland, has developed the Earth Alert Notification System through NASA-funded SBIR research. The system is designed to provide information to first responders during disastrous events and thereby improve situational awareness. The system is completing a 90-day demonstration period designed to fully test the entire system.

NASA also had one of its service providers as a Tibbetts winner this year. The Louisiana Business and Technology Center (LBTC) has played a major role in promoting the SBIR program for 13 years. LBTC provides support to small business for SBIR proposal writing, as well as business development assistance such as developing business plans and marketing strategies.

More information about the Tibbetts Awards, including a listing of all of this year's winners, as well as information about the nomination process, can be found at *http://www.sba.gov/SBIR/*. NASA encourages successful SBIR companies to consider submitting self-nominations.

For more information, contact Pam Guzzone at NASA Goddard Space Flight Center, 301/286-3687, *plguzzon@pop700.gsfc.nasa.gov* Please mention you read about it in *Innovation*.

Small Business Flying High

INSTRUMENTS ON NASA SATELLITES AND aircraft will be collecting the data needed by scientists to answer some of the most challenging questions faced today concerning our atmosphere and the formation of stars and planets. One of those instruments is a passive radiometer, which measures infrared or heat radiation from the atmosphere or space as seen through a telescope. Scientists use this information in a number of ways. When looking at the Earth's atmosphere, observations in infrared vision allow scientists to calculate the amount of several environmentally important gases, such as ozone and carbon monoxide. When looking toward interstellar space, this data allows scientists to estimate the quantities of important chemicals, such as water and carbon in the clouds of dust and gas that are believed to collapse to form solar systems such as our own.

Working under a NASA SBIR contract managed at the Jet Propulsion Laboratory, DeMaria ElectroOptics developed a compact, efficient near-infrared (2.5 Thz) laser that extends the observation range of passive radiometers. Observations made by earlier passive radiometers were limited to the longer wavelength range of the infrared spectrum. The new source from DeMaria ElectroOptics increased the observation range to shorter wavelengths. The stable signal from the laser is used in converting the observed infrared radiation to a lower frequency signal for measuring its intensity.

Scientists focus on the infrared range of the spectrum for two reasons. First, atoms and molecules emit infrared radiation even at the very cold temperatures of interstellar space. Thus, these gases, which are invisible to us through a regular telescope, are visible using an infrared telescope. Second, different atoms and molecules have their own characteristic signatures or particular wavelengths at which they emit infrared radiation. Therefore, infrared radiation can be used to estimate the amount of different chemicals in the interstellar medium or the Earth's atmosphere.

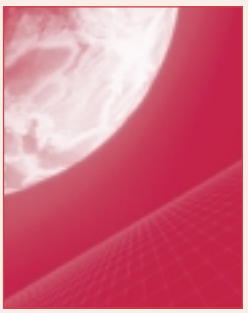
Under another contract with the Jet Propulsion Laboratory, DeMaria ElectroOptics is providing a near-infrared laser for the Microwave Limb Sounder instrument that will be a part of the Earth-Observing System (EOS) AURA mission. With a launch date in June 2003, the AURA satellite, with four major scientific instruments, will map data on the Earth's atmosphere on a global scale. With its near-infrared capability, the Microwave Limb Sounder will measure the OH concentration in the upper atmosphere—a key factor in ozone chemistry and understanding the cause of the hole in the ozone layer.

WITH ITS NEAR-INFRARED CAPABILITY, THE MICROWAVE LIMB SOUNDER WILL MEASURE THE OH CONCENTRATION IN THE UPPER ATMOSPHERE— A KEY FACTOR IN OZONE CHEMISTRY AND UNDERSTANDING THE CAUSE OF THE HOLE IN THE OZONE LAYER.

DeMaria ElectroOptics also supplied a near-infrared laser being used in the development of the radiometer that will fly on the SOFIA mission—an effort between NASA and the German space agency, DLR. In a joint effort, the agencies will fly a large infrared telescope on a Boeing 747 aircraft. At ground level, the atmosphere filters out most of the infrared radiation from space; however, most of the infrared radiation is observable at stratospheric altitudes. Observations made from the aircraft when flying in the stratosphere will support a comprehensive study of the processes that lead from cold clouds of gas and dust in the Interstellar Medium to the formation of stars and planetary systems. SOFIA will also examine the dust and gas in the vicinity of our Galactic Center, and search for the signature of a black hole. The first flight is scheduled for late 2002.

For more information, contact Bryon Jackson at the Jet Propulsion Laboratory, 818/354-1246, *Bryon.L.Jackson@jpl.nasa.gov*. Please mention you read about it in *Innovation*.

TECHNOLOGY OPPORTUNITY SHOWCASE



Technology Opportunity Showcase *highlights some unique technologies that NASA has developed and that we believe have strong potential for commercial application. While the descriptions provided here are brief, they should provide enough information to communicate the potential applications of the technology. For more detailed information, contact the person listed. Please mention that you read about it in* Innovation.

CARES/*Life* Software Tool

To be commercially viable, microelectromechanical (MEMS) devices must be manufactured cost-effectively with high yield rates, and they must survive their intended application environment over the projected service life. It is an essential element in product development that a risk assessment be performed prior to full-scale manufacture. The Life Prediction branch of the NASA Glenn Research Center, a world leader in brittle-material design methodology development, has developed CARES/*Life* (Ceramics Analysis and Reliability Evaluation of Structures/Life) software that characterizes and predicts the integrity of brittle-material structures.

CARES/*Life* is already a widely recognized program used by hundreds of organizations worldwide. It has won a NASA Software of the Year Award, an R&D 100 Award and a Federal Laboratory Consortium Award. Several organizations have already requested this program for MEMS-specific applications, including sensor arrays for spacecraft, piezoelectric ceramic sticks for inkjet print heads and micro-turbine development. CARES/*Life* is suitable for MEMS reliability evaluation of brittle materials and is currently used for polycrystalline (isotropic) materials. It is the most useful for harsh environment applications that challenge the capabilities of existing materials. CARES/*Life* quantifies the inherent wide dispersions in strengths introduced by etching-induced pits and edge flaws, and it enables part integrity assessment prior to manufacture, reliability to be tracked as a function of the part's time in service under sustained and repeated loadings, and rapid prototyping of design before the actual hardware is produced. The CARES/*Life* design methodology combines the statistical nature of strength-controlling flaws with the mechanics of crack growth to predict the probability that a brittle material component will fail as a function of its time in service. This methodology accounts for multi-axial stress states, concurrent flaw populations, slow crack growth, proof testing and component size and scaling effects.

CARES/*Life* interfaces with commercially available finite element software such as ANSYS or ABAQUS. It can also use test data from specimen rupture tests to obtain the statistical (Weibull) and fatigue parameters required for device life assessment. CARES/*Life* is currently available as beta-test software to US-based organizations (foreign distribution is considered on a case-by-case basis).

For more information, contact Noel N. Nemeth at NASA Glenn Research Center, 216/433-3215, *Noel.N.Nemeth@grc.nasa.gov*. Please mention you read about it in *Innovation*.

Remote Pressure Transducer Health Check

Kennedy Space Center is seeking companies to license and commercialize the Remote Pressure Transducer Health Check technology—a process for remotely checking various parameters of a pressure transducer to determine if it requires calibration. In remote locations, wide margins of safety are used to compensate for the degradation of the measurement devices installed over time. This leads to a need for additional resources, increased technical support and the added costs associated with these needs. This technology is designed to accurately determine the health of the measurement device by an in situ check of the sensor's major operating parameters.

Potential commercial uses of the technology include use in pressure transducer manufacturing; by end-users of pressure transducers; for oil company pipeline maintenance; and for water company pipeline maintenance. This technology permits remote measurements of the sensitivity, linearity, hysteresis, temperature, thermodynamic pressure and repeatability of a pressure transducer; decreases redundant measurements through remote-signal-indicating calibration; decreases the amount of time and possible errors during system failures; and extends the life of devices installed in an operating environment by reducing the number of times a pressure transducer requires removal for laboratory calibration. In the health check procedure, a fixed change, either above or below, in ambient pressure is measured. This is performed by first sealing an enclosed volume around the transducer with a valve. A piston inside the sealed volume is then driven forward, compressing the enclosed gas, thereby increasing the pressure. A fixed pressure below ambient pressure is obtained by opening the valve, driving the piston forward, sealing the valve and then retracting the piston. The output of the pressure transducer is recorded for both the over pressuring and the under pressuring.

By comparing the data with data taken during a preoperative calibration, the health of the transducer is determined from the linearity, hysteresis and the repeatability of its output. The addition of an adiabatic decompression/expansion phase to the health check allows the comparison of the thermometer and the manometer through the thermodynamic equation of state for the gas. This would determine if there exists a constant offset error in the manometer.

For more information, contact Lynne Henkiel at NASA Kennedy Space Center, 321/867-8130, *Lynne.henkiel-1@ksc.nasa.gov*. Please mention you read about it in *Innovation*.

NCTN DIRECTORY

Moving Forward

NASA Field Centers

Ames Research Center
Selected technological strengths are Information Technologies, Aerospace Systems, Autonomous Systems for Space Flight, Computational Fluid Dynamics and Aviation Operations.

Carolina Blake
Ames Research Center
Moffett Field, California 94035-1000
650/604-1754
cblake@mail.arc.nasa.gov

Dryden Flight Research Center
Selected technological strengths are Aerodynamics, Aeronautics Flight Testing, Aeropropulsion, Flight Systems, Thermal Testing and Integrated Systems Test and Validation.

Jenny Baer-Riedhart
Dryden Flight Research Center
Edwards, California 93523-0273
661/276-3689
jenny.baer-riedhart@mail.dfrc.nasa.gov

Glenn Research Center
Selected technological strengths are Aeropropulsion, Communications, Energy Technology and High-Temperature Materials Research, Microgravity Science and Technology, and Instrumentation Control Systems.

Larry Viterna
Glenn Research Center
Cleveland, Ohio 44135
216/433-3484
Larry.A.Viterna@grc.nasa.gov

Goddard Space Flight Center
Selected technological strengths are Earth and Planetary Science Missions, LIDAR, Cryogenic Systems, Tracking, Telemetry, Command, Optics and Sensors/Detectors.

George Alcorn
Goddard Space Flight Center
Greenbelt, Maryland 20771
301/286-5810
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Jet Propulsion Laboratory
Selected technological strengths are Deep and Near Space Mission Engineering and Operations, Microspacecraft, Space Communications, Remote and In-Situ Sensing, Microdevices, Robotics and Autonomous Systems.

Merle McKenzie
Jet Propulsion Laboratory
Pasadena, California 91109
818/354-2577
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Johnson Space Center
Selected technological strengths are Life Sciences/Biomedical, Spacecraft Systems, Information Systems, Robotic and Human Space Flight Operations.

Charlene Gilbert
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Houston, Texas 77058
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Kennedy Space Center
Selected technological strengths are Emissions and Contamination Monitoring, Sensors, Corrosion Protection and Biosciences.

Jim Aliberti
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Langley Research Center
Selected technological strengths are Aerodynamics, Flight Systems, Materials, Structures, Sensors, Measurements and Information Sciences.

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Marshall Space Flight Center
Selected technological strengths are Materials, Manufacturing, Non-Destructive Evaluation, Biotechnology, Space Propulsion, Controls and Dynamics, Structures and Microgravity Processing.

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Huntsville, Alabama 35812
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vernotto.mcmillan@msfc.nasa.gov

Stennis Space Center
Selected technological strengths are Propulsion Systems, Test/Monitoring, Remote Sensing and Non-Intrusive Instrumentation.

Kirk Sharp
Stennis Space Center
Stennis Space Center, Mississippi
39529-6000
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NASA's Business Facilitators

NASA has established several organizations whose objectives are to establish joint-sponsored research agreements and incubate small start-up companies with significant business promise.

Bill Musgrave
Ames Technology Commercialization Center
San Jose, CA
408/557-6820

Greg Hinkebein
Mississippi Enterprise for Technology
Stennis Space Center, MS
228/688-3144

Wayne P. Zeman
Lewis Incubator for Technology
Cleveland, OH
440/260-3300

David Kershaw
Florida/NASA Business Incubation Center
Titusville, FL
321/267-5601

Bridget Smalley
University of Houston/NASA Technology Center
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713/743-9155

Joanne Randolph
Business Technology Development Center
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Martin Kaszubowski
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Ann Lansinger
Emerging Technology Center NASA Business Incubator
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Small Business Programs

Carl Ray
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Paul Mexcur
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paul.mexcur@pop700.gsfc.nasa.gov

NASA-Sponsored Commercial Technology Organizations

These organizations were established to provide rapid access to NASA and other federal R&D agencies and to foster collaboration between public and private sector organizations. They also can direct you to the appropriate point of contact within the Federal Laboratory Consortium. To reach the RTTC nearest you, call 800/642-2872.

Ken Dozier
Far West Technology Transfer Center
University of Southern California
Los Angeles, CA 90007
213/743-2353

William Gasko
Center for Technology Commercialization
Westborough, MA 01581
508/870-0042

David Bridges
Economic Development Institute
Georgia Institute of Technology
Atlanta, GA 30332
404/894-6786

Gary F. Sera
Mid-Continent Technology Transfer Center
Texas A&M University
College Station, TX 77840
979/845-8762

Charlie Blankenship
Technology Commercialization Center, Inc.
Newport News, VA 23606
757/269-0025

Pierrette Woodford
Great Lakes Industrial Technology Center
Battelle Memorial Institute
Cleveland, OH 44070
440/734-0094

Joseph P. Allen
National Technology Transfer Center
Wheeling Jesuit University
Wheeling, WV 26003
800/678-6882

Dan Winfield
Research Triangle Institute Technology Applications Team
Research Triangle Park, NC 27709
919/541-6431

NASA ONLINE

Go to the **NASA Commercial Technology Network (NCTN)** on the World Wide Web at ***http://nctn.hq.nasa.gov*** to search NASA technology resources, find commercialization opportunities and learn about NASA's national network of programs, organizations and services dedicated to technology transfer and commercialization.

Events

The Second Astrobiology Science Conference will take place April 7–11, 2002 at NASA Ames Research Center. For more information, visit *http://astrobiology.arc.nasa.gov/conferences/2001/ABSciConf/index.html*

The 9th Annual Great Moonbuggy Race will be held April 12 and 13, 2002 on the grounds of the US Space and Rocket Center. Students are required to design a vehicle that addresses a series of engineering problems that are similar to problems faced by the original Moonbuggy team. The race is sponsored by NASA Marshall Space Flight Center, the US Space and Rocket Center, American Institute of Aeronautics and Astronautics, Sci-Quest and the Aerospace Development Center of Alabama. For more information, visit *http://moonbuggy.msfc.nasa.gov*

Reminder: NASA will be showcasing medical-imaging technologies at the International Society for Optical Engineers SPIE Conference, February 23–28, 2002 in San Diego, CA. For more information, go to *www.nasatechnology.com*

Multimedia

NASA's popular educational Web site, ***Space Place***, has announced a new Spanish-language version for children and their families.

The Web site, *http://spaceplace.jpl.nasa.gov*, and its new Spanish companion, *http://spaceplace.jpl.nasa.gov/espanol*, serve children 8–13 years of age. The site contains approximately 40 activities, including games and "amazing facts" about space, Earth and NASA.

Books

NASA has just published ***Exploring the Cosmos***, the fifth volume of ***Exploring the Unknown***, an ongoing series of reference books essential for anyone interested in the history and development of the US civil space program.

Selected documents of interest to those involved in both space history and policy are grouped into three thematic chapters, with an introductory essay for each subject. Chapter one is devoted to the origins and early organization of space science; chapter two covers NASA's planetary exploration efforts; and the third chapter details space-based astronomy and astrophysics.

The book is for sale from the US Superintendent of Documents and from the NASA Information Center. Details on ordering the volume are available at *http://history.nasa.gov/what.html*

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